

[54] **FLUID PRESSURE ACTUATED SWITCH WITH PRESTRESSED DIAPHRAGM**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 18,673, March 11, 1970, abandoned.

[52] U.S. Cl. **200/83 Y, 200/83 B, 200/83 T**

[51] Int. Cl. **H01h 35/34**

[58] Field of Search **200/83 T, 83 Y, 83 R, 200/83 B**

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[57] **ABSTRACT**

A fluid pressure responsive switch including a housing, a fluid inlet in the housing, a partition member in the

housing, a first diaphragm effectively positioned between the fluid inlet and the partition member to define a first chamber between the partition member and the first diaphragm, a switch member on the housing, a second diaphragm effectively positioned between the partition member and the switch member and defining a second chamber between the partition member and the second diaphragm, a plurality of apertures in the partition member for effecting communication between the first and second chambers, a single flapper valve member attached to the partition for normally preventing communication between the first and second chambers, said first diaphragm being deflected upon the sensing of fluid pressure from an external source by said first diaphragm to cause fluid to be moved through said first chamber to said second chamber through said plurality of apertures, and bleed aperture means in the partition member for permitting bleeding of fluid from the second chamber to said first chamber after said external fluid pressure is no longer sensed and said flapper valve member is closed, said second diaphragm actuating said switch means upon the movement of fluid into said second chamber. The first diaphragm can be prestressed as desired during fabrication so as to vary the sensitivity of the switch.

The present invention relates to an improved fluid pressure actuated switch and more particularly to a switch of this type for use in conjunction with laundry tubs which are located below sewer line level, and also for use in other applications where fluid pressures are to be measured.

8 Claims, 6 Drawing Figures

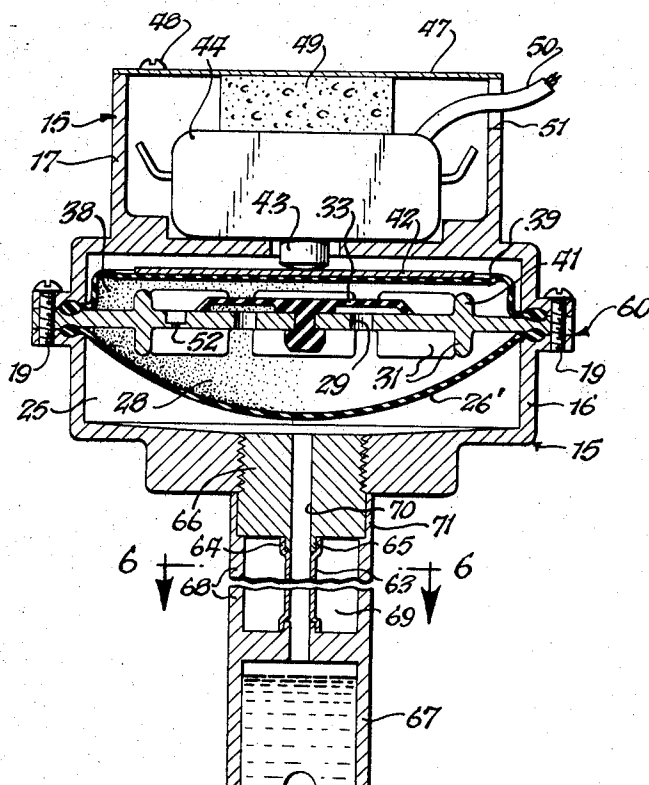


Fig. 1.

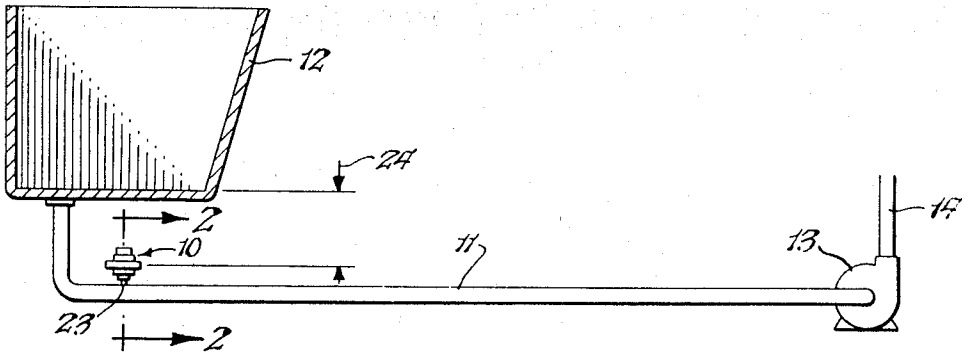


Fig. 2.

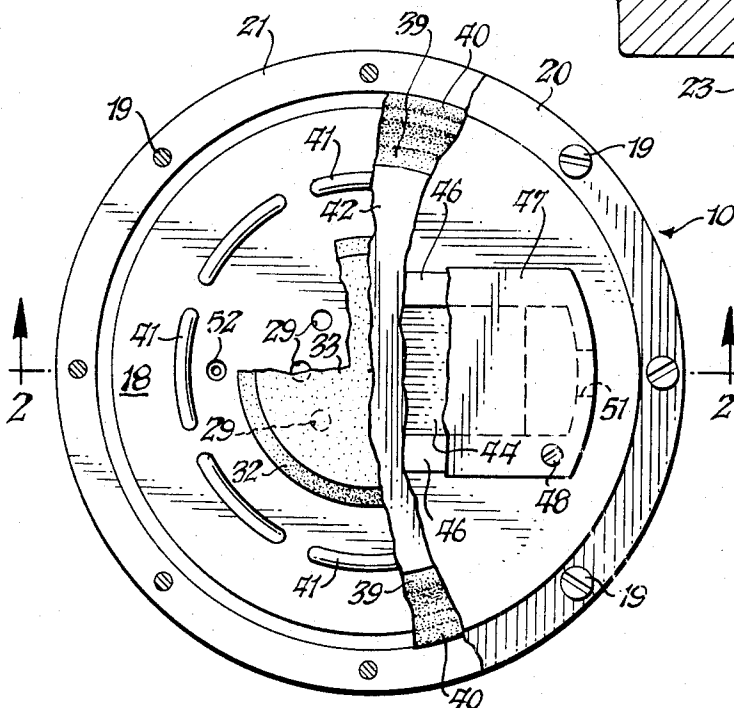
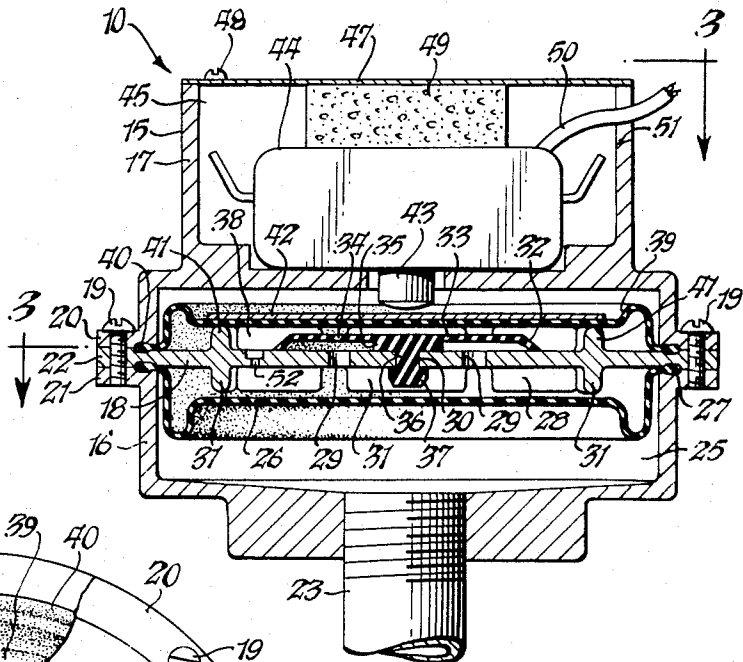


Fig. 3.

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Fig. 4.

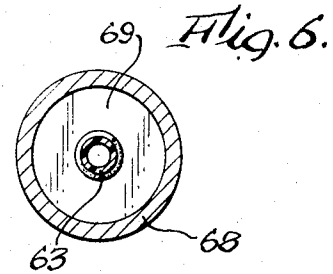
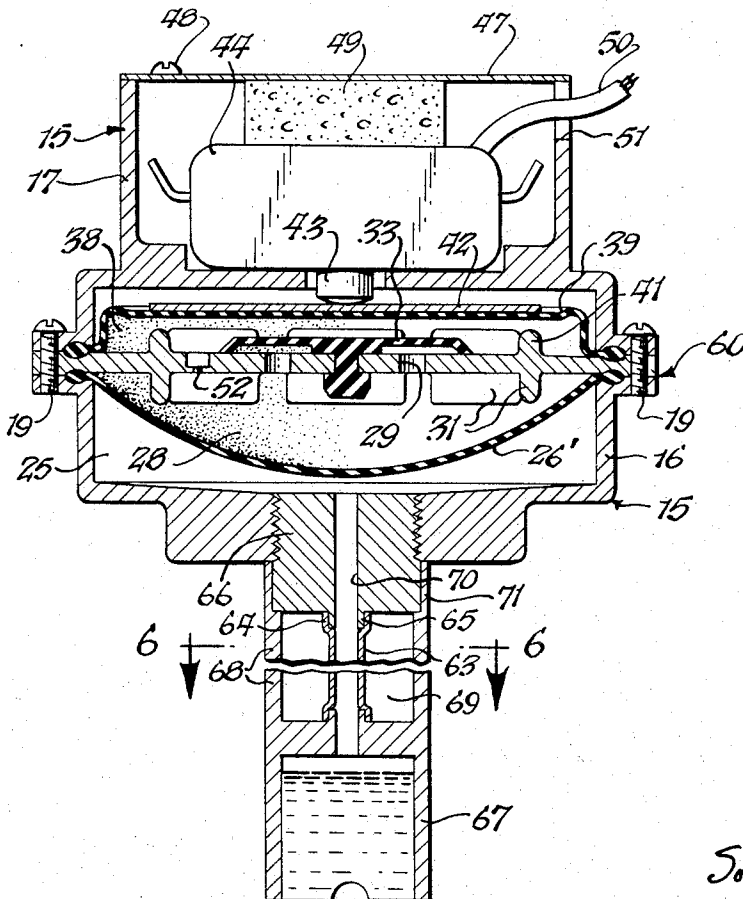
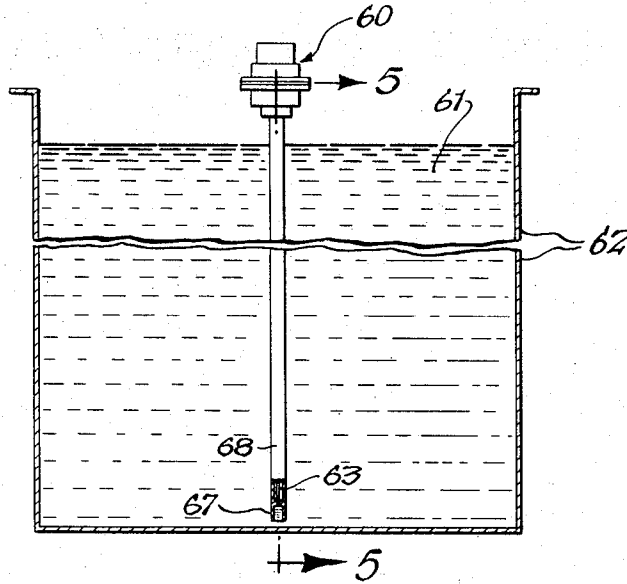


Fig. 5.

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FLUID PRESSURE ACTUATED SWITCH WITH PRESTRESSED DIAPHRAGM

The present application is a continuation-in-part of application Ser. No. 18,673, filed Mar. 11, 1970, now abandoned.

In certain housing constructions the laundry tubs in the basement are located below sewer line level, which precludes gravity flow to the sewer. Accordingly, pumps are associated with tubs of this type, and these pumps are normally actuated by manual switches. This is subject to certain shortcomings. If there should be drainage into the tub when a person is not present to actuate the switch, there can be an overflow onto the basement floor. On the other hand, if a person should actuate the switch to empty the tub and for any reason not turn the switch off within a short time after the tub was drained, continued operation of the pump could cause the electric motor driving it to burn out. Thus, manually actuated pumps were a source of inconvenience to a householder having the foregoing type of plumbing.

Also in the past it was very difficult to utilize a standard pressure responsive switch for different pressure ranges without extensive modification to suit the particular needs under consideration. This type of modification not only often required the replacement of parts, but also often required changing the various dimensions of the critical parts of the switch so as to enable it to perform satisfactorily under the particular conditions under consideration.

It is accordingly the primary object of the present invention to provide an improved pressure actuated switch for energizing the motor associated with a laundry tub pump or the like in response to sensing a predetermined level of liquid in the drain conduit, said switch being extremely simple in construction and highly reliable in operation.

Another object of the present invention is to provide an improved fluid pressure actuated switch which utilizes a single flapper valve to cover a plurality of apertures in an unique manner to permit rapid flow of fluid through said apertures in a first direction, but prevent flow in the reverse direction.

A further object of the present invention is to provide an improved fluid pressure actuated switch in which the various component parts which are subject to wear or deterioration can be replaced simply and easily without the use of complex tools.

Yet another object of the present invention is to provide an improved pressure responsive switch which can have its sensitivity altered for operation in different pressure ranges by merely varying the amount that the pressure sensing diaphragm is prestressed, thereby permitting a single switch to be modified simply for use in various applications without requiring different parts or changes in design thereof.

A still further object of the present invention is to provide an improved pressure sensing system for measuring the depth of liquid without permitting the liquid to contact the working parts of the switch. Other objects and attendant advantages of the present invention will readily be perceived hereafter.

The improved pressure responsive switch of the present invention includes a housing having a fluid inlet, a partition member in the housing, a first diaphragm effectively positioned between the fluid inlet and the par-

tion member to define a first chamber between the partition member and the first diaphragm, switch means mounted on the housing, a second diaphragm effectively positioned between the partition member and the switch means for selectively actuating the switch means, and said second diaphragm and said partition member defining a second chamber therebetween, a plurality of apertures in the partition member for effecting rapid communication between the first and second chambers, a single flapper valve member mounted in operative relationship to said plurality of apertures, and a bleed aperture in the partition member for permitting bleeding of fluid from the second chamber to the first chamber after the closing of the flapper valve after the transfer of fluid from the first to second chambers has been completed.

Also in accordance with the present invention the improved pressure responsive switch described above may be constructed with the first diaphragm under any desired degree of prestress to thereby adjust its sensitivity to function to the range of pressures to which it will be subjected. In other words, if the diaphragm is prestressed to a greater degree, then it will be able to be actuated by smaller pressures and vice versa. Thus, the same switch can be modified in an extremely simple manner for use in different applications for different pressure ranges by merely modifying the amount to which the pressure sensing diaphragm is prestressed, without requiring the addition of new or different parts.

Also in accordance with the present invention a system is provided for sensing the depth of liquid in a tank without subjecting the switch to contact with the liquid. In this respect, a conduit which provides an air column is placed in communication with the chamber in the switch which senses pressure. The liquid in the tank will exert a force on the air column in proportion to the depth of the liquid in the tank so as to cause the varying pressure of the air column on the pressure sensing portion of the switch to actuate it.

The various aspects of the present invention will be more fully understood when the following portions of the specification are read in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic view of the improved switch of the present invention shown in its normal environment in relationship to a laundry tub and drain pipe associated therewith;

FIG. 2 is a cross sectional view of the improved switch taken substantially along line 2-2 of FIG. 3;

FIG. 3 is a fragmentary view taken substantially in the direction of arrows 3-3 at different elevations of FIG. 2 and showing the various components of the switch in plan;

FIG. 4 is a schematic fragmentary side elevational view showing the improved switch of the present invention in association with a liquid tank to measure the depth of liquid therein;

FIG. 5 is a fragmentary cross sectional view of a modification of the switch disclosed in FIGS. 1-3 and taken substantially along line 5-5 of FIG. 4 and showing the manner in which the fluid pressure sensing diaphragm is prestressed to change the response characteristics of the switch; and

FIG. 6 is a cross sectional view taken substantially along line 6-6 of FIG. 5 and showing the relationship between the pressure sensing tube and a protective shield associated therewith.

The improved switch 10 of the present invention is tapped into drain pipe 11 of laundry tub 12. Pump 13 is actuated by switch 10 to pump water from conduit 11 to conduit 14 which leads to a sewer which is above the level of pipe 11.

Switch 10 includes a housing 15 consisting of a molded plastic lower half 16 and a molded plastic upper half 17 with a molded plastic partition member 18 therebetween, these parts being attached to each other by means of a plurality of screws 19 which extend through annular rims 20 and 21 and the outer peripheral portion 22 of circular partition member 18. The lower housing portion 16 receives a nipple 23 which is in communication with the inside of conduit 11. Rivets may be used instead of screws 19.

Whenever there is a head of water 24, the fluid pressure within chamber 25 will cause resilient diaphragm 26 to deflect upwardly, considering that the outer annular edge 27 of circular diaphragm is sandwiched between partition member 18 and flange 20 to provide a fluid-tight joint. The air in chamber 28 will be forced upwardly through apertures 29 which are spaced in a circle about central flapper valve receiving aperture 30 in partition 18. Actually there are eight apertures 29 equidistantly spaced in a circle to permit the volume of air from chamber 28 to be forced from chamber 28 almost instantaneously with the upward deflection of diaphragm 26. At this point it is to be noted that diaphragm 26 is of the cross sectional configuration shown in FIG. 2 so that it returns to this shape when the fluid pressure within chamber 25 is relieved. To prevent diaphragm 26 from being distorted to too great an extent, a series of lugs 31 are spaced in the form of a circle and formed integrally with partition member 18 to provide stops limiting the amount of upward deflection of diaphragm 26.

After the air passes through apertures 29 it deflects the outer annular peripheral lip 32 of flapper valve 33 which is of circular configuration and formed of a suitable resilient material such as rubber. The circular central portion 34 of flapper valve 33 is formed integrally with enlarged spacer member 35 which is formed integrally with a reduced neck portion 36 having an enlarged tip 37 formed integrally therewith. The neck 36 is received in flapper valve receiving opening 30 in partition 18 and the assembly is made by merely forcing the resilient end 37 through aperture 30 until it locks in position in the manner shown in FIG. 2. This construction permits rapid mounting of the flapper valve on partition 18 in a semi-permanent manner, in the sense that it can be removed easily and replaced, if required. It can thus be seen that a single flapper valve 33 covers a plurality of apertures 29, thereby obviating the necessity for a flapper valve to be associated with each aperture 29. Thus, a large volume of air can be rapidly forced from chamber 28 through apertures 29 and past flapper valve 33 into chamber 38 which lies between partition member 18 and upper resilient diaphragm 39 which is formed as shown in FIG. 2 and has its outer annular edge portion 40 clamped between upper housing portion edge 20 and flange 22 of partition 18. While diaphragm 26 and 39 have a slightly different cross sectional configuration, they can be made identical and installed as mirror images of each other, thereby reducing the number of different parts which are required.

Lugs 41 are analogous to lugs 31 shown in FIG. 3 but extend from the opposite side of partition 18 for the

purpose of preventing circular diaphragm 39 from deflecting too far downwardly. A circular metal plate 42 is cemented to the top of diaphragm 39 and upon the upward deflection of diaphragm 39 due to the forcing of the air in chamber 38, plate 42 will engage switch element 43 which extends outwardly from electrical switch 44 which is securely held within chamber 45 in upper portion of housing 17. It is to be noted that there is no connection between switch element 43 and plate 42. This construction permits simple replacement of the switch 44, if this is required. The sides of switch 44 fit between opposed side walls 46 and a plate 47 is attached to the upper portion of housing 17 by means of screws 48 with a packing 49 bearing on switch 44 to hold it firmly in position. There is no other connection between switch 44 and the housing. Lead wires 50 attached to switch 44 extend through opening 51 in the housing for attachment to a suitable source of electricity.

The actuation of switch 44 by means of diaphragm 39 will start an electric motor associated with pump 13 to empty tub 12. As soon as the pump 13 starts, chamber 25 will be evacuated. This will tend to draw diaphragm 26 downwardly which in turn will cause flapper valve 33 to resume its closed position. Thereafter the air in upper chamber 38 can return to lower chamber 28 through bleed orifice 52 in partition 18. The length of time which it takes this bleeding to occur will determine the length of time that switch 44 continues to actuate motor 13. It may well be that this bleeding will be completed before all of the water is removed from tub 12. Thus, on the stopping of motor 13, the head of water will again cause upward deflection of diaphragm 26 to initiate the foregoing cycle of operation of switch 10. In this manner switch 10 will cycle on and off for a period of time until such time as tub 12 is completely emptied. Thus, whenever switch 10 senses a head of water which is at least as great as head 24, pump 13 will be energized and it will cycle continuously until such time as tub 12 is completely emptied. Preferably the head 24 should be no greater than the length of the vertical pipe below the drain, so that there will be no standing water in the tub. Actually head 24 should preferably be smaller than shown in FIG. 1.

Thus, switch 10 obviates the possibility that tub 12 will overflow, as could be the case if a manual switch were used. Furthermore, there is no possibility that there can be any standing water in tub 12 which could cause undesirable foul smells. In short, the switch 10 is fully automatic to provide only the necessary amount of evacuation of tub 12 when required, and switch 10 will shut off the motor when there is no water in the tub. This prevents burning out of the pump motor, which could occur if it were run dry.

While the fluid between diaphragms 26 and 39 has previously been described as air, it will be appreciated that it can be any other gas or liquid, such as water or ethylene glycol.

A modified form of the switch 10 shown in FIGS. 1-3 is shown in FIGS. 4 and 5. All of the components of modified switch 60 are identical to the components of switch 10 shown in detail in FIGS. 2 and 3. The only difference is that lower diaphragm 26' of FIG. 5, which is analogous to diaphragm 26 of FIG. 2, has been prestressed so as to assume the shape shown in FIG. 5. Before it was prestressed it had the shape of diaphragm 26 shown in FIG. 2. The prestressing is effected by apply-

ing a vacuum to chamber 25 through a conduit such as 23 shown in FIG. 2 during assembly and holding this vacuum until after screws 19 have assembled the switch. This will trap a larger body of air in chamber 28 of switch 60 than is trapped in this chamber in the embodiment of FIG. 2. Furthermore, diaphragm 26' will remain stressed after the vacuum applied to chamber 25 is released. It will be noted, however, that diaphragm 39 of FIG. 5 is bowed upwardly more than this same diaphragm in the embodiment of FIG. 2. This is a result of the equalization of the pressure within chambers 28 and 38, as a result of the tendency of diaphragm 26' to return to its normal unstressed condition. The upward bowing of diaphragm 39 takes up the play in switch element 43, without actuating the switch 44.

The prestressing which is applied to the diaphragm 26' will augment the fluid pressure force applied to chamber 25 during operation of the valve so that the same valve shown in FIG. 2, except with diaphragm 26' distended as shown in FIG. 5, will be responsive to smaller pressure forces to actuate switch such as 44 than a switch with an unstressed diaphragm 26 such as shown in FIG. 2. This results from the fact that the amount of stress of the diaphragm 26' adds to the fluid pressure actuating force in chamber 25 to actuate the switch, thus permitting a smaller fluid pressure force to actuate the switch than if diaphragm 26' was not prestressed. Furthermore, it will be appreciated that the greater the force which is used to prestress or distend diaphragm 26', the less will be the fluid pressure force applied to chamber 25 which will be required to actuate the switch. Thus, it will be appreciated that a valve such as shown in FIG. 2 can be modified to be responsive to different pressure ranges by merely distending diaphragm 26' different amounts. Furthermore, if desired, diaphragm 26' need not necessarily originally be of the shape of diaphragm 26 shown in FIG. 2 but may be of any other suitable shape which will permit it to be prestressed incidental to the assembly of the switch. Plate 42 on diaphragm 39 prevents the latter from assuming a shape like diaphragm 26'. It is to be again noted that all of the components of switch 60 are identical to the components of switch 10 shown in FIG. 2.

The switch 60 of FIGS. 4 and 5 is especially suitable for use in a system for sensing the depth of liquid 61 in tank 62. This is because of the extreme sensitivity of a switch such as 60 having a distended or prestressed diaphragm 26'. The system of FIG. 4 includes a sensing tube 63 having an end 64 mounted on nipple 65 extending downwardly from plug 66 which is threaded into housing portion 15. Sensing tube 63 is in communication with bore 70 in plug 66, and bore 70 is in communication with chamber 25. The lower portion of tube 63 is in communication with an inverted cup portion 67. It will be appreciated that when switch 60 and sensing tube 63 are held vertically in a tank 62 and liquid is conducted into the tank, air will be trapped in tube 63 and the greater the depth of liquid 61 in the tank, the more liquid will rise into cup portion 67 and the greater will be the liquid pressure on the column of air in tube 63 to thereby vary the air pressure exerted against diaphragm 26'. Once a predetermined air pressure is sensed in chamber 25 by diaphragm 26', the switch 60 will produce the switching action described in detail above relative to switch 10. As the depth of liquid in tank 62 decreases, the pressure of the liquid on the col-

umn of air in tube 63 will decrease until such time as diaphragm 26' returns to its normal prestressed condition, and the air trapped in chamber 38 will pass through bleed 52 to chamber 28 so that switch 44 will become deactuated, as described above in detail relative to FIG. 2.

It is to be noted that a protective shield 68 surrounds tube 63 to protect it from the liquid 61 and shield 68 has a portion 71 suitably mounted in fluid-tight relationship on plug 66. If desired, space 69 may be filled with insulating material so as to minimize the effect of temperature on the air in tube 63.

While tube 63 has been shown straight in FIGS. 4 and 5, it will be appreciated that it can be flexible and can assume any desired curved orientation as is required to reach relatively inaccessible locations. In such a use, protective tube 68 may be eliminated.

It is also to be noted that cup portion 67 is designed so that the liquid entering it from the bottom cannot rise to a level where it enters sensing tube 63. Therefore impurities or solids in the liquid cannot build up on the inside of tube 63. Furthermore it will be appreciated that the pressure switches described above can be used to sense the pressure of any liquid, and are not restricted to applications where water pressure is being sensed.

While switch 10 was described above as cycling on and off when subjected to a head of water, it will be appreciated that this occurs only when the head fluctuates about the actuation pressure. However, when the head is above this actuation pressure, switch 10 will run continuously because the head of water will maintain diaphragm 26 deflected upwardly. After the water in the tub falls below the above-mentioned actuation pressure pump 13 will usually be able to empty the tub within the time period that it takes for air to bleed from upper chamber 38 to lower chamber 28, thereby avoiding the above-described cycling.

What is claimed is:

1. A fluid pressure responsive switch comprising a housing, a fluid inlet in said housing, first and second diaphragms in said housing to define a first chamber therebetween, fluid in said first chamber, a second chamber in communication with said fluid inlet, said second chamber being located on the opposite side of said first diaphragm from said first chamber, switch means on said housing actuatable by said second diaphragm after the sensing of a predetermined pressure in said second chamber by said first diaphragm, and means for presetting the sensitivity of said switch wherein said means comprises said first diaphragm being prestressed beyond the amount it would be stressed by the ambient pressure of fluid in said first chamber, whereby a force is exerted by said first diaphragm which acts in conjunction with the force of fluid in said second chamber, and the sensitivity of said switch being dependent on the amount said first diaphragm is prestressed.

2. A fluid pressure responsive switch as set forth in claim 1 including pressure sensing tube means for providing a column of gas, said pressure sensing tube means having first and second ends with said first end being in communication with said second chamber, and exposure means on said second end of said pressure sensing tube for exposure to a force creating a compressive force on said gas in said pressure sensing tube

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means to thereby cause said force to be sensed in said second chamber.

3. A fluid pressure responsive switch as set forth in claim 2 wherein said exposure means comprises inverted cup means for permitting liquid to rise therein.

4. A fluid pressure responsive switch as set forth in claim 1 including a partition member located between said first and second diaphragms so as to divide said first chamber into third and fourth chambers, aperture means in said partition member, valve means associated with said aperture means to permit flow of fluid from said third chamber to said fourth chamber upon the sensing of fluid pressure in said second chamber while preventing reverse flow from said fourth chamber to said third chamber, and bleed aperture means in said partition member for permitting flow of fluid from said fourth chamber to said third chamber at a controlled rate upon the relieving of said sensed fluid pressure in said second chamber.

5. A fluid pressure responsive switch as set forth in claim 4 wherein said housing comprises first and second halves having first and second rims, respectively, and wherein said fluid inlet is in said first half of said housing, and wherein said partition member is relatively thin and has an outer edge portion located between said first and second rims, a first outer edge on said first diaphragm located between said outer edge portion and said first rim, a second outer edge on said second diaphragm located between said outer edge portion and said second rim, a plurality of fastener means extending through said first and second rims and said outer edge portion for holding said first and second halves of said housing and said partition member and said first and second diaphragms in assembled relationship, and wherein said aperture means comprise a plurality of apertures in said partition member, and wherein said valve means comprise a flapper valve having a first portion attached to said partition member and a second portion overlying said plurality of apertures, said second portion being circular and substantially planar and lying substantially parallel to said partition member in said fourth chamber, said first portion being centrally attached to said second portion, said

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first portion including first and second spaced enlarged portions with a reduced portion therebetween, a flapper valve holding aperture in said partition member, said reduced diameter portion fitting in said flapper valve holding aperture, said first enlarged portion being remote from said second portion of said flapper valve means and being located in said third chamber, said second enlarged portion being in contiguous relationship to said second portion and being located in said fourth chamber to space said second portion from said partition member, said first enlarged portion being resilient for squeezing through said flapper valve holding aperture, and said second portion including an annular lip on its outer periphery for engaging said partition member to effect a sealing relationship relative to said plurality of apertures.

6. A fluid pressure responsive switch as set forth in claim 5 including a fifth chamber in said housing for receiving said switch means, a cover plate on said housing for permitting selective access to said switch means, said housing including portions for locating said switch means therein including a second partition member for supporting said switch means, a third aperture in said second partition means, and a switch element on said switch means extending through said third aperture for engagement by said plate.

7. A fluid pressure responsive switch as set forth in claim 6 wherein said second partition member includes wall means thereon for positively positioning said switch means in a predetermined location in said fifth chamber.

8. A fluid pressure responsive switch as set forth in claim 7 including a first series of lugs formed integrally with said partition member and extending into said third chamber, a second series of lugs formed integrally with said partition member and extending into said fourth chamber, said first and second series of lugs being positioned in the form of first and second circles, respectively, for selective direct engagement by said first and second diaphragms, respectively, for preventing said first and second diaphragms from contacting the remaining portions of said partition member.

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